Vol.7 No.1 (2024)

Journal of Applied Learning & Teaching

ISSN : **2591-801X**

Content Available at : **http://journals.sfu.ca/jalt/index.php/jalt/index**

Utilizing head simulation training in dental school education: Time and cost implications

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Keywords

Cost;
head simulator;
oral health professionals;
time.

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Article Info

Received 29 November 2023
Received in revised form 10 February 2024
Accepted 21 February 2024
Available online 29 February 2024

DOI: https://doi.org/10.37074/jalt.2024.7.1.17

Abstract

Studies have suggested that the head simulator was a useful instrument for imparting hand skills for tooth removal in dental school. Although head simulator models are used by students to develop their dental hand skills, they have noteworthy limitations that restrict the breadth of knowledge and abilities that students can learn. The purpose of this current study was to determine cost and time as barriers to the effectiveness of head simulator use in dental schools. Regarding the perceived time requirements for dental courses, most participants (51.6%) disagreed that the use of head simulators extended the course duration. In terms of the availability and cost of head simulators, 40% of respondents found the availability to be above average or excellent, while 20% rated it below average or very poor. The current study suggests that the cost of head simulators did not affect the availability of the devices to oral health professionals during their school years. And the head simulator use did not extend the duration of the dental course.

Introduction

Head simulators are used as experiential learning tools for dental students and oral health professionals to develop proficient dental skills (Li et al., 2021). Assessing the relationship between cost, time, and head simulator usage in dental schools is crucial to optimize resource utilization. The cost of these simulators varies widely, influenced by model type, quality, features, materials used, installation expenses, and accessory costs (Kamińska et al., 2019; Centre for Immersive Technologies et al., 2021). This cost factor is pivotal in determining their effectiveness in educational settings.

The amount of time required for students and professionals to become proficient in using head simulators is also important. It hinges on the simulator type, complexity, student training levels, and practitioners' training needs (Chernikova et al., 2020; McGleenon & Morison, 2021). Evaluating the relationship between cost, time, and head simulator utilization should be considered in their integration into health profession training. These simulators offer a realistic training environment that diminishes procedural error risks during dental practices (Li et al., 2021). Moreover, they enhance the learning experience by providing an immersive, interactive educational setting (Hamilton et al., 2021).

To examine the connection between simulator use, skill mastery, confidence levels, time investment, and associated costs, various assessment methods are viable. Using surveys and questionnaires enables an optimal evaluation of these variables among oral health professionals post-head simulator use in dental schools (Roopa & Rani, 2012). These assessment tools will gauge professionals' simulator experiences, skill levels, confidence in patient procedures, and perceptions regarding associated time and cost factors.

Health Belief Model theoretical framework

The Health Belief Model (HBM) theoretical framework was adapted to understand the perceived barriers of cost and time in the effect that simulation training has on oral health professionals during their studies in dental institutions. The Health Belief Model (HBM) suggests that an individual's choice to engage in actions aimed at preventing or treating an illness is influenced by their perceptions of the likelihood and severity of the condition, as well as the perceived benefits and obstacles associated with its prevention or treatment (Remien et al., 2019). The exploration of the benefits and barriers of the HBM provides insight into the factors that influence educational institutions' assessments to adopt the head simulator technology against perceived barriers such as the high cost of the equipment, the lack of realism compared to real patients, and the need for additional training and time that comes with using it (Khodaveisi et al., 2021). HBM can suggest interventions that can be designed to address both the perceived benefits and barriers of head simulator training to increase participation and improve the quality of oral health care by reducing the perceived barriers of cost and time (Sanaeinasab et al., 2022).

The perceived barriers of cost and time can be explored to understand the downside of head simulator training for oral health care professionals during their studies and future engagement in this type of training. The perceived barrier of cost is a common obstacle to head simulator training. Oral healthcare professionals may perceive that the cost of the training is expensive on the part of the institution, considering the cost-benefit ratio of the training (Finocchiaro et al., 2021). A study suggested that institutions may not have access to funding for purchasing the simulator technology to integrate into the training of health professionals (San Diego et al., 2022). Utilizing the Health Belief Model's perceived barrier of cost in this study validates the concerns raised by oral healthcare professionals regarding the expenses associated with simulator training for health profession students.

The perceived time barrier is also a significant barrier to head simulator training. Solvik and Struksnes (2018) suggested that healthcare professionals perceived that they did not have enough time to participate in training because of the limited simulators available and the high demands of many students wanting hands-on practice during their clinical sessions. According to Jones et al. (2015), HBM-perceived barriers could be significant factors that prevent individuals from engaging in health-promoting behaviors. In the context of head simulator training, perceived barriers of cost and time can prevent oral health care professionals from participating in this type of training in the future, even when they recognize the potential benefits.

Medical safety is a top responsibility, and oral healthcare workers without practical experience face major consequences. Furthermore, the use of head simulators in dental schools may be hampered by time constraints. Coupled with the lower availability of head simulator technologies in dental schools, oral healthcare students may not have enough practice time with the few health simulators in their schools (Arigbede et al., 2015). In the case of appropriate availability of head simulators, it is possible that dental students already have a finite amount of practice and learning time, so adding head simulator training could detract from other crucial components of their education (Farag & Hashem, 2021).

Nonetheless, the HBM theoretical framework provides valuable insight into the potential challenges that may arise with the use of head simulator technology. Exploring the barriers of the HBM on the effectiveness of head simulators in impacting the clinical practice of oral health professionals, dental educators can promote the integration or exclusion of head simulators that will ultimately lead to improved dental education and better patient outcomes.

This current study aimed to determine oral health professionals' perceived time and cost drawbacks associated with the use of simulators during their dental studies.

Methodology

The research project was approved by the university's Institutional Review Board, having satisfied the requirement of obtaining and submitting investigator research training certificates in human subjects' protection and financial conflict of interest (IRB number: SI20230505-001).

Research design

A survey was conducted through Jotform (version 4.0), a secure online data collection and analysis platform, using a quantitative research approach to gather data through a purposeful sampling strategy selecting participants with the expertise to address the researcher's inquiries, specifically targeting dental hygienists, dentists, and dental assistants. The questionnaires, employing a 5-point Likert scale, included two sections, with Section 1 having 7 questions and Section 2 containing 12 questions, which investigated the barriers of cost and time associated with utilizing dental school resources. The Likert scale parameters used were "never seldom to almost always" for time, "strongly disagree to strongly agree" for cost, "very poor to excellent" for the number of available devices, and a range of time. The validation of the 5-point Likert scale was conducted by a subject matter expert and a research methodologist for reliability. The survey was constructed based on existing survey templates (Avedian, 2014). Prior to data collection, both a subject matter expert (SME) in oral health education and a research methodologist analyzed the questionnaires for content validity.

Sample and recruitment

The population targeted for this study included dental hygienists, dentists, and dental assistants. A solicitation email was dispatched to prospective participants affiliated with the Nebraska Dental Association. Email addresses were acquired through the procurement of a mailing list from the Nebraska Department of Regulation and Licensure. The email invited recipients to voluntarily partake in the research study. The involvement of participants from the Ghana Dental Association was facilitated by sharing the research description and survey hyperlink on the association's WhatsApp platform.

The survey hyperlink directed participants to a secure data collection page on Jotform. On the Jotform platform, participants received comprehensive information regarding the study's purpose, procedures, potential risks, and benefits. Before participating in the study, written informed consent was obtained from the participant. Importantly, no personally identifiable information was collected during the study, and the data underwent anonymization during analysis. The responses from the participants were recorded for analysis and securely stored on the principal investigator's computer device, which is accessible only to the principal investigator and protected by a password.

Confidentiality was a priority and was stated in the brief description of the research study recruitment invitation that explained the proposed study and the importance of the study to health professionals' program design. Participants could opt out of the study at any time with no penalty. The survey was delivered to each participant just once to maintain data integrity and prevent participants from taking the survey more than once. Assigning unique identities, validating participant eligibility, imposing time constraints, monitoring IP addresses, and performing duplication detection during data cleaning ensured that each participant's survey was recorded only once, maintaining data accuracy and internal consistency reliability.

Data management and analysis

To answer the research question, "What are oral health professionals' perceived time and cost drawbacks with the use of simulators during their studies?", descriptive and inferential statistics (Laerd Statistics, n.d.) were used to determine relationships between various variables. A correlation analysis was also conducted, the significance level set at $p<0.05$, following Laerd Statistics (n.d.). In addition, the studied population demographics were described using measures of central tendency. The cleaned data was validated in Airtable and analyzed with the Statistical Package for the Social Sciences (SPSS, version 26).

Results

Demographic analysis

The ideal sample size for this study was 278, using a sample size calculator with a confidence level of 95%, a margin of error of 5%, and a population of 1000 (www.qualtrics.com). The survey response rate of 11.7%, with 117 responding out of a total population of 1000. Among them, 55 identified themselves as male, 61 as female, and one preferred not to disclose their gender. An analysis of the age distribution revealed that 10 individuals (8.5%) belonged to the 20 to 29 age range, indicating a substantial presence of young professionals. The age bracket of 30 to 39 years had a larger representation, with 33 participants (28.2%) falling within this category. There were 24 individuals (20.5%) aged between 40 to 49 years, signifying a significant portion of this age group. The largest segment consisted of participants aged 50 and above, accounting for 50 individuals (42.7%), highlighting the involvement of experienced professionals.

Research findings

Out of the 117 participants, a total of 60 participants responded yes to engaging with head simulators in their dental program. The study explored oral health professionals' perceptions regarding time and cost drawbacks associated with the use of simulators during their studies. Hypotheses formulated were, the null hypothesis (H_0) that there are no perceived time and cost drawbacks among oral health professionals who use simulators during their studies, and the alternate hypothesis (H_a) that time and cost of

technology are perceived as major barriers in the use of head simulators for dental education.

The descriptive statistics (Table 1) analyzed responses from 60 dental program participants concerning the extension of dental course time due to head simulator use.

Table 1: Frequency distribution for profession and utilization of simulation during dental program.

Profession/Occupation	Did you use any simulation during your dental program?		
	No	Yes	Total
Dentist	42	46	88
Dental/Oral Hygienist	14	13	27
Dental Assistant	1	1	2
Total	57	60	117

In total, most respondents (51.6%, n=31) disagreed that the simulator significantly lengthened their course duration, supported by percentages across various agreement levels (see Table 2).

Table 2: Perceived extension of time requirements for dental programs due to head simulator use among dental program participants.

Rating	*n*	%
Strongly Agree	1	1.7
Agree	8	13.3
Neutral	20	33.3
Disagree	23	38.3
Strongly Disagree	8	13.3
Total	60	100

Participants' perceptions of the number of available head simulators concerning their cost were assessed, with the majority (40%) responding to the head simulators' availability being "Average" (Table 3).

Table 3: Perceived cost drawback for dental programs due to head simulator use among dental program participants.

Rating	*n*	%
Excellent	12	20.0
Above Average	12	20.0
Average	24	40.0
Below Average	8	13.3
Very Poor	4	6.7
Total	60	100

Pearson correlation analysis revealed a weak inverse relationship between extended time requirements for a course and the cost of head simulators (-0.146), suggesting insufficient evidence for a significant linear connection (Table 4).

Table 4: Correlations between dependent variables of perceived time and cost drawbacks with the use of simulators during studies.

		Extended time requirements for a course	Cost of head simulators and the number of head simulators available
Extended time requirements for a course	Pearson Correlation	1	-0.146
	Sig. (2-tailed)	--	0.266
	N	60	60
Cost of head simulators and the number of head simulators available	Pearson Correlation	-0.146	1
	Sig. (2-tailed)	0.266	--
	N	60	60

Note. Time Requirements for a course and cost of head simulators: Pearson correlation: -0.146, significance (2-tailed): 0.266. Cost of Head Simulators and Number of Head Simulators Available: Pearson correlation: 1, significance (2-tailed): 0.266.

The regression analysis showed a significant relationship ($F = 4.987$, $p = 0.029$) between the duration of simulator use during studies and the potential extension of course time (Table 5).

Table 5: ANOVA analysis of the use of the head simulator in dental schools extended the time requirements for the dental course.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	4.195	1	4.195	4.987	0.029
Residual	48.789	58	0.841	--	--
Total	52.983	59	--	--	--

Note. A higher F-value indicates a more pronounced relationship. For this study, the F-statistic was determined to be 4.987. The significance of the relationship between the independent and dependent variables is evaluated by the associated p-value (p-value < 0.05).

The regression coefficients (Rate the amount of time spent practising with head simulators during your studies) confirmed the positive influence of simulator usage on course duration (see Table 6). This analysis supports the notion that increased time spent using head simulators during studies positively impacts the extension of course time, translating that there was no extension for the dental program duration. This provides substantial insights into the perceptions and correlations concerning simulator usage, time implications, and associated costs.

Table 6: Coefficients of the regression model on the use of the head simulator in dental schools that extended the time requirements for the dental course.

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t-value	Sig.
(Constant)	1.548	0.450	--	3.442	0.001
Rate the amount of time you spent practicing with head simulators during your studies.	0.295	0.132	0.281	2.233	0.029

Note. The constant coefficient is 1.548. This represents the expected value of the dependent variable (Simulators_Time_Req_Course) when the independent variable (Time_Training_Simulators_Studies) is zero.

Discussion

In determining "What are oral health professionals' perceived time and cost drawbacks with the use of simulators during their studies?", most of the participants disagreed with the perception that their engagement with head simulators significantly extended the dental course time requirements. This finding suggested from the perspective of the participants that head simulators did not substantially prolong the duration of their educational programs. About 2 in 10 participants affirmed that the use of head simulators resulted in the extension of course time requirements, whereas about 7 in 10 participants strongly disagreed that the simulator had a notable effect on prolonging their course time requirements. According to Horsley and Wambach (2015), this result emphasises the argument that well-designed programs that integrate simulations enhance students' learning experiences and skill development without significantly increasing program duration. The use of simulation improves the effectiveness of clinical training and compensates for inadequate faculty members (Horsley & Wambach, 2015).

To understand how oral health professionals who used simulators during their dental program perceived the availability of head simulators regarding their cost, participants were asked to rate this aspect. The results suggested that a substantial number of participants found the availability of head simulators to be in line with their cost expectations. Analyzing the number of participants who considered the availability of head simulators to meet the needs of oral health professional students suggested that most participants did not view the cost of head simulators as a significant drawback during their education.

The use of head simulators did not impose significant time or cost burdens during the educational pursuits of oral health professionals. This result aligns with Nabovati et al. (2022) and Rubbelke et al. (2014), who found that students can engage with simulation devices without the burden of additional expenses. In addition, the results suggest that health profession programs investing in simulators can be a cost-effective approach to health professions' education in the long term, although the initial financial commitment in simulator technology may be substantial (Maloney & Haines, 2016). This contradicts the initial limitation suggestion that the cost associated with acquiring and upkeeping simulators, along with the investments in time and resources for training, may impose constraints on the availability of simulation-based training for practitioners (Datta et al., 2012). Therefore, the results emphasized that head simulators can reduce the time and cost required for training (Boeldt et al., 2019). Although initially suggested as being barriers based on the HBM theoretical framework, the current study elucidated that usage time and cost of head simulators do not pose challenges in the training of oral health professional students. This leads to comprehending the use of head simulators to assess its efficacy for oral health professional students in becoming proficient in clinical (Nabovati et al., 2022) performance.

Conclusion and recommendation

The study established, contrary to the initial hypothesis, that the use of head simulators does not lead to a substantial extension of course duration or increased financial burdens. Acknowledging the tangible benefits of integrating technology into the training of oral health professionals, this knowledge can be used by current dental educators to optimize training and better prepare dental students for the challenges they will face as practitioners.

References

Arigbede, A., Denloye, O., & Dosumu, O. (2015). Use of simulators in operative dental education: Experience in southern Nigeria. *African Health Sciences, 15*(1), 269–277. https://doi.org/10.4314/ahs.v15i1.35

Avedian, A. (2014). *Survey design*. Harvard Law School. https://hnmcp.law.harvard.edu/wp-content/uploads/2012/02/Arevik-Avedian-Survey-Design-PowerPoint.pdf

Boeldt, D., McMahon, E., McFaul, M., & Greenleaf, W. (2019). Using virtual reality exposure therapy to enhance treatment of anxiety disorders: Identifying areas of clinical adoption and potential obstacles. *Frontiers in Psychiatry, 10*, 773. https://doi.org/10.3389/fpsyt.2019.00773

Centre for Immersive Technologies, Mushtaq, F., & Mon-Williams, M. (2021, July 19). *Simulation-based dental education: An international consensus report*. https://doi.org/10.31219/osf.io/c27pe

Chernikova, O., Heitzmann, N., Stadler, M., Holzberger, D., Seidel, T., & Fischer, F. (2020). *Simulation-based learning in higher education: A meta-analysis. Review of Educational Research, 90*(4), 499–541. https://doi.org/10.3102/0034654320933544

Datta, R., Upadhyay, K., & Jaideep, C. (2012). Simulation and its role in medical education. *Medical Journal Armed Forces India, 68*(2), 167–172. https://doi.org/10.1016/S0377-1237(12)60040-9

Farag, A., & Hashem, D. (2021). Impact of the haptic virtual reality simulator on dental students' psychomotor skills in preclinical operative dentistry. *Clinics and Practice, 12*(1), 17–26. https://doi.org/10.3390/clinpract12010003

Finocchiaro, M., Cortegoso Valdivia, P., Hernansanz, A., Marino, N., Amram, D., Casals, A., Menciassi, A., Marlicz, W., Ciuti, G. & Koulaouzidis, A. (2021). Training simulators for gastrointestinal endoscopy: Current and future perspectives. *Cancers, 13*(6), 1427. https://doi.org/10.3390/cancers13061427

Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education, 8*, 1–32. https://doi.org/10.1007/s40692-020-00169-2

Horsley, T. L., & Wambach, K. (2015). Effect of nursing faculty presence on students' anxiety, self-confidence, and clinical performance during a clinical simulation experience. *Clinical Simulation in Nursing, 11*(1), 4–10. https://www.sciencedirect.com/science/article/abs/pii/S1876139914001741

Jones, C. L., Jensen, J. D., Scherr, C. L., Brown, N. R., Christy, K., & Weaver, J. (2015). The Health Belief Model as an explanatory framework in communication research: Exploring parallel, serial, and moderated mediation. *Health Communication, 30*(6), 566–576. https://doi.org/10.1080/10410236.2013.873363

Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R. E., Avots, E., Helmi, A., Ozcinar, C., & Anbarjafari, G. (2019). Virtual reality and its applications in education: Survey. *Information, 10*(10), 318. https://doi.org/10.3390/info10100318

Khodaveisi, M., Oshvandi, K., Bashirian, S., Khazaei, S., Gillespie, M., Masoumi, S. Z., & Mohammadi, F. (2021). Moral courage, moral sensitivity and safe nursing care in nurses caring of patients with COVID-19. *Nursing Open, 8*(6), 3538–3546. https://doi.org/10.1002/nop2.903

Laerd Statistics. (n.d.). *Descriptive and inferential statistics.* https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php

Li, Y., Ye, H., Ye, F., Liu, Y., Lv, L., Zhang, P., Zhang, X., & Zhou, Y. (2021). The current situation and future prospects of simulators in dental education. *Journal of Medical Internet Research, 23*(4), e23635. https://doi.org/10.2196/23635

Maloney, S., & Haines, T. (2016). Issues of cost-benefit and cost-effectiveness for simulation in health professions education. *Advances in Simulation (London, England), 1*, 13. https://doi.org/10.1186/s41077-016-0020-3

McGleenon, E., & Morison, S. (2021). Preparing dental students for independent practice: A scoping review of methods and trends in undergraduate clinical skills teaching in the UK and Ireland. *British Dental Journal, 230*, 39–45. https://doi.org/10.1038/s41415-020-2505-7

Nabovati, E., Jeddi, F. R., Ghaffari, F., & Mirhoseini, F. (2022). The effects of simulation training on learning of health information systems: A scoping review. *Journal of Education and Health Promotion, 11,* 4. https://pubmed.ncbi.nlm.nih.gov/35281403/

Remien, R. H., Stirratt, M. J., Nguyen, N., Robbins, R. N., Pala, A. N., & Mellins, C. A. (2019). Mental health and HIV/AIDS: The need for an integrated response. *AIDS (London, England), 33*(9), 1411–1420. https://doi.org/10.1097/QAD.0000000000002227

Roopa, S., & Rani, M. S. (2012). Questionnaire designing for a survey. *Journal of Indian Orthodontic Society, 46*(4), 273–277. https://www.researchgate.net/publication/235801675_Questionnaire_Designing_for_a_Survey

Rubbelke, C. S., Keenan, S. C., & Haycraft, L. L. (2014). An interactive simulated electronic health record using Google Drive. *Computers, Informatics, Nursing: CIN, 32*(1), 1–6. https://doi.org/10.1097/CIN.0000000000000043

San Diego, J. P., Newton, T. J., Sagoo, A. K., Aston, T. A., Banerjee, A., Quinn, B. F. A., & Cox, M. J. (2022). Learning clinical skills using haptic vs. phantom head dental chair simulators in removal of artificial caries: Cluster-randomized trials with two cohorts' cavity preparation. *Dentistry Journal, 10*(11), 198. https://doi.org/10.3390/dj10110198

Sanaeinasab, H., Saffari, M., Taghavi, H., Karimi Zarchi, A., Rahmati, F., Al Zaben, F., & Koenig, H. G. (2022). An educational intervention using the health belief model for improvement of oral health behavior in grade-schoolers: A randomized controlled trial. *BMC Oral Health, 22*(1), 94. https://doi.org/10.1186/s12903-022-02132-2

Solvik, E., & Struksnes, S. (2018). Training nursing skills: A quantitative study of nursing students' experiences before and after clinical practice. *Nursing Research and Practice*, 8984028. https://doi.org/10.1155/2018/8984028